An Economic Analysis of Hospital Utilization Patterns in the General Acute Portion of the Alberta Hospital System

R. H. M. Plain

Alberta
Human Resources Research Council

AN ECONOMIC ANALYSIS OF HOSPITAL UTILIZATION PATTERNS IN THE GENERAL ACUTE PORTION OF THE ALBERTA HOSPITAL SYSTEM

Richard H. M. Plain
University of Alberta
April 1972

FOREWORD

Opportunity, social and economic, is essential to human development. Since its inception, therefore, the Human Resources Research Council has concerned itself with the study of social and economic opportunities available to Albertans. Inevitably, such studies involve the investigators in the economic, political, legal, social, and educational life of the community.

In April, 1969, the Council sponsored a major Symposium on Social Opportunity. Working papers were presented by 40 scholars from the three Alberta universities. The papers covered inequalities of opportunity in such areas as law, politics, health, education, and economics.

Following the symposium six major areas were identified as important for intensive study and research: political opportunity, the economics of educational opportunity, employment opportunity, health opportunity, the opportunity of equality before the law, and economic opportunity. Studies in these areas became the responsibility of HRRC's Socio-Economic Opportunities study unit.

Professor Plain's study, AN ECONOMIC ANALYSIS OF HOSPITAL UTILIZATION PATTERNS IN THE GENERAL ACUTE PORTION OF THE ALBERTA HOSPITAL SYSTEM, was initiated under the direction of Dr. Karol Krotki, then Coordinator of HRRC's Socio-Economic Opportunity Studies Unit.

The study has been completed under the direction of Dr. J. MacMillan, Associate Director of HRRC, in charge of the Socio-Economic Studies Unit. The manuscript was prepared for printing by the staff of HRRC's User Services Unit.

Views or conclusions expressed in this report are those of the author, and should not be construed as expressing the opinion of the Alberta Human Resources Research Council.

Human Resources Research Council
Edmonton, Alberta

April, 1972

CONTENTS

LIST OF TABLES

PREFACE

This study was carried out during the course of the summer and fall of 1970 and the spring of 1971 under the auspices of a research grant given by the Alberta Human Resources Research Council. The study is a result of the joint activities of myself, David Emerson (Chief Research Assistant) and Mr. L. S. Wilson.

The basic data utilized in the study were obtained from the Alberta Department of Health, Hospital Services Division. Mr. A. H. McLean, Chief Research and Development Officer, provided us with a substantial amount of invaluable and compilation stages of our work.

Mr. Emerson has born the main brunt of the writing chores while Mr. Wilson provided the requisite programming skills. Mr. Marcel Benoit provided a wide range of general assistance.

The basic specification and format of the study, in addition to any errors, are my responsibility.

Richard H. M. Plain
Departments of Community Medicine
(Health Services Division) and
Economics
University of Alberta

CHAPTER I

INTRODUCTION

During the past two years the health care industry in Canada has been subjected to a host of generalized criticisms centered around the purported inefficiency with which resources have been allocated within the health care section of the Canadian economy. An examination of the data produced by the Department of National Health and Welfare[1] suggests that there is some basis for this concern; however, it should be noted that no concerted effort has been made to relate the benefits received by consumers to the costs incurred in providing various sets of health services.

THE TRADITIONAL METHOD OF ALLOCATING HEALTH RESOURCES

The objective of any government health provision program should be stated in terms of the maximization of net social benefits. This basic specification has escaped the notice of various government departments and agencies as well as individual hospitals, medical associations and other vested interest groups. The net result of this state of affairs is that the traditional manner in which resources have been allocated has been the identification of "needs", as perceived by various types of health personnel and other "interested" parties. Once the "needs" are identified, political and social pressures are exerted until the "perceived needs" are interpreted as a demand

for additional health services by consumers. After sufficient pressure has been exerted through the media and through the testimony of various vested interest groups with respect to the ethical and social merits of fulfilling the newly discovered "demand" by consumers, the various levels of government either singly or in conjunction meet the "demand" by allocating sufficient funds to provide the required services and facilities. Little attention is paid to the selection of the least costly method of delivering the additional services, unless the least costly methods of producing health services -- existing services are produced within the confines of the conventional wisdom and value system of the medical, nursing and related para-medical groups within the industry - accidentally fall within the existing production patterns determined by the de-centralized, uncoordinated activities of groups of hospitals, medical practitioners and public health personnel.

This type of allocation process led to the development of the attitude that the basic economic constraint - the scarcity of resources - did not apply to the health care field. The situation is best illustrated by the widely held belief that "among all other things good health has the highest priority". This widely held belief was re-enforced by the virtual "blank cheque" given to hospitals and medical practitioners under the recent Medicare legislation and the Hospital Insurance and Diag-

nostic Act in the latter part of the '50's.

The role of health care administrators in this allocation process consisted basically of ensuring that reasonable sets of accounts were kept and that political and social objectives of various power blocks were harmonized or balanced, both on an inter-and intra-institutional basis. Economic issues, in particular economic analysis, were at best of peripheral concern to administrators actively engaged in the day-to-day operation of the delivery system.

CHANGES IN THE SYSTEM

In the past 30 months or more the provincial and federal governments have become extremely worried over the substantial increase in health care costs.[2] Expenditures on health care services increased from $1,047,403,000 to $3,887,467 between 1957 and 1969. In Alberta the overall expenditures increased from $82,863,000 to $311,016,000. The average annual percentage in expenditures in the province moved from 9.38 percent between 1961 and 1965 to 15.2 percent between 1965 and 1969.

The two largest items in total health care expenditures in Alberta resulted from the provision of general acute hospital and physician services. ($153,387,000 and $78,800,000 respectively in 1969). Both of these areas experienced rates of increase amounting to 15.2 percent and 19.5 percent between 1965 and 1969.[3]

The net result of the rapid escalation of health care costs has been the realization on the part of governments that the "needs" method of allocating resources could not be continued in a world of limited resources. The "needs approach" ensured that the demand for health services was virtually insatiable.

The switch from the "needs" approach to a more rational allocation of resources resulted in the introduction of economic questions. The provincial government introduced a so-called global budgeting system into the Alberta hospital system. This simply amounted to framing the following traditional economic problem. "Maximize the quantity of hospital services, given a fixed budget outlay."

Legislation was passed in 1971 creating a Hospital Commission which among other things was given sufficient authority to ensure that a systematic approach towards the allocation of hospital services was taken in all regions of the province. This would require among other things the introduction and development of a number of economic considerations and skills on the part of all health care administrators in the province.

Similar comments could be made in a number of other areas in the health care field. The point to note is that in 1971 the health care system has been forced to address itself seriously to the economic as well as the

social and political questions involved in allocating health care facilities and services. The problem of establishing explicit measurements of the benefits of health care services as well as systematically identifying programs in terms of ends rather than inputs (Planning Program Budgeting Systems [P.P.B.S.])has just commenced - or is being considered. Priorities will have to be established on the basis of benefit-cost analysis, implying that the impact of various programs in terms of changes in morbidity and mortality patterns in segments of the population located in various regions of the province will have to be explicity set out. Clearly this means that a substantial period of time will be required before the economic skills of administrators will be sufficiently developed to provide the requisite analytical inputs required in rationalizing the manner in which policies are formulated.

PURPOSE OF THE STUDY

The foregoing brief description indicates that the health care field is undergoing a considerable number of changes. One factor that should be noted is that a considerable amount of theoretical as well as applied work must be carried out in the field of health care economics before the effects of a number of existing policies can be evaluated. The vast majority of existing economic

models, tools and concepts can be transferred to the health care economic field; however, one area in health care economics has proven to be rather "difficult to handle" in terms of conventional economic theory. The area in question is centered around the problem of establishing a micro-economic theory of the firm which applies to the public sector. The traditional coverage in Public Economics (Finance) is extremely weak in this area, yet it is clear that it is necessary to provide a model which allows one to determine the equivalent in the public sector of the profit maximizing output of the firm in the private sector. This implies that considerable thought must be given to the establishment of the basic behavioral postulates which govern the actions of the public firm.

The basic purpose of this study is to estimate the effects of changes in the supply of beds in the Alberta hospital system on mean stay and the number of cases treated within the general acute portion of the system.

A secondary purpose is to test certain hypotheses related to the supply and utilization of hospital beds derived from a model of the public firm promulgated by M. Feldstein. In fact, we were extremely interested to see whether the qualitative direction of change (signs) of the hypotheses that derived from Feldstein's model - albeit with certain heroic assumptions - "hold up" and whether the effect of changes in the bed supply in Alberta

are comparable to the estimates Feldstein produced for the British hospital system.

It should be noted that Chapter III simply amounts to an elaboration of the model set out in Feldstein's basic work. This is an unnecessary duplication of effort as far as economists are concerned. However, no apology is made, since hopefully this monograph will be examined outside of the economics field.

One final point should be made. The data used to estimate the various regression parameters have not been included in the study because the space taken up by these data would increase the report to an impractical size, and because recourse can easily be made to the primary source of the data, namely the Alberta Hospital Insurance Commission. Similarly, the bulk and complexity of the data preclude delineating the various hospital service areas used in the study. Any interested readers can obtain more detailed information by writing to R. H. M. Plain, Department of Economics, University of Alberta, Edmonton.

CHAPTER II

THE PROBLEM

THE ALLOCATION PROCESS

The allocation of hospital services - like many other such problems involving scarcity - is appropriately dealt with in an economic framework. From the point of view of the province as a whole, the ultimate objective should be the provision of an "appropriate" quantity and quality of service through some implicit equating of marginal social costs and marginal social benefits.

It is convenient, for the purposes of this study, to view this allocation process as occurring at two levels. At the provincial level the government attempts to arrive at an "optimal" allocation of scarce resources <u>between</u> various hospitals in the system. At the micro-level, allocations must be made <u>within a given hospital</u>.

At the more aggregative level there can be associated with any government provision policy:[4]

(1) a set of available facilities - both directly and indirectly controlled;

(2) a pattern of utilization of facilities;

(3) the associated costs - both those incurred by government and those paid by others; and

(4) the ultimate effect of this care on the health of the community.

It is clear that this can be interpreted as the

maximization (by the relevant government authority) of a social welfare function the arguments of which are measures of community health, the costs to the government and other costs. This maximization is subject to constraints imposed by the relationship between government provision, total availabilities, costs, utilization, and "health" of the community. That is, the government authority should attempt to equate marginal social benefits accruing to hospital services with marginal social cost.

The general problem is treated by Theil[5], when he considers the decision-maker as attempting to maximize a quadratic preference function subject to a set of linear constraints.[6] The arguments of the preference function comprise both controlled and uncontrolled variables (the former variables are those over which the decision-maker has some control). The constraints incorporate the uncontrolled variables as linear equations. The system is then solved by means of the Lagrangean technique which yields optimal values for both controlled and uncontrolled variables.

It should be noted that the above is merely a description of how the government, as a surrogate for the people, should attempt to conduct this particular allocation problem; it is not intended to describe the process actually used.

Due to several exogenous restrictions, this study

will deal with the less aggregative micro-type of model. First, there has been no attempt to analyze the effects of government provision policy on the way health resources are used. Second, there is no agreement on the way in which community health should be measured. Third, as a result of doctors viewing their problems as occuring under conditions of unconstrained maximization[7] there has been little interest, on the part of the medical profession, in estimating opportunity costs of alternative methods of treatment.

A note is in order on the unconstrained behavior of the medical profession, mentioned before. Casual empiricism suggests that the product of most medical schools has an ingrained tendency to regard all <u>his</u> patients as deserving the best possible medical care. This tends to exclude the possibility of medical doctors consciously considering the economic opportunity costs of a given type of treatment for a given type of patient. Thus, doctors may admit patients to hospitals when, if they were aware of the economic opportunity costs, they would not do so. Again, policies such as the above could induce a consideration of opportunity costs so that adequate care could be provided for society at less cost.

This analysis considers government expenditures and supply programmes to be parametric while the designated variables will be associated with utilization patterns

within the hospitals. Interest will be centred upon a set of hypotheses about how the variables can be expected to change with any given change in the supply parameter.[8] The theoretical model will facilitate the derivation of hypotheses which can be tested against empirical data.

It is intended that the results of the study should have the potential to be presented to the appropriate decision-makers as a monitoring service. If such information can show how the individual decision-makers could modify their behavior so that the overall goals of the system are more nearly achieved, then it is conceivable that these people would alter their behavior in a desirable way.

The apparent emphasis on monitoring information can be justified when the nature of the decision-making unit of a hospital is made clear. The quotation marks about the term "administrator" are intended to remind the reader that no single individual can be considered the decision-maker for a particular hospital. The "administrator" is to be interpreted as a hypothetical individual whose behavior reflects the combined behavior of doctors, nurses (to a lesser extent) and the actual administrator. By far the largest component of the "administrator" are the doctors. It is the doctors who, by and large, decide whether a patient should be admitted to hospital and how long he should stay. The decision-making unit, being composed of "n" relatively independent individuals, could possibly be influenced by the provision of information

designed to edify rather than command.

There are, however, other methods of exerting pressure on the relevant decision-makers. A judicious controlling of supplies (hospital beds, for example) can restrict the freedom with which patients can be hospitalized. A supply cutback, for example, could induce higher utilization rates and less hospitalization in cases when it is not necessary. Similarly, pressure could be brought to bear regarding the length of stays.

THE INAPPLICABILITY OF THE COMPETITIVE MODEL IN THE HEALTH INDUSTRY

In a perfectly competitive setting, such nonoptimal results are not a problem. Perfect competition, it is recalled, is premised by decentralized decision-making on the part of utility-maximizing consumers and profit-maximizing producers. If certain behavioral and technical restrictions are imposed on the model[9], and a price adjustment mechanism[10] is introduced, then there is assurance of the existence of a competitive equilibrium (having certain optimality properties) in addition to a mechanism capable of transforming disequilibrium situations into equilibrium situations.

Clearly, hospitals are not profit maximizers[11] and further, to quote Feldstein:[12]

> The process by which hospital beds are distributed among types of patients and diagnoses ... is very different from the allocation of resources in the production of other consumer goods and services. The observed pattern of use cannot be regarded

> as the result of an optimizing process involving consumer's preference functions and the associated production possibility frontier. Although the patients are the consumers of hospital care, it is primarily the doctors who allocate hospital services ... Moreover, neither the patient nor the doctor is required to consider the financial or opportunity costs associated with a particular decision to consume hospital resources.

Thus, the market for hospital services is not characterized by the appropriate behavior of consumers and producers nor by the existence of a price adjustment mechanism. In the absence of the latter, although efficient allocations still exist, there is no assurance that they will be reached. Further, although individual doctors may be providing the best possible care for their patients (which may be optimal from both the doctor's and patient's point of view) this does not imply that marginal social costs will be equated to marginal social benefits in the provision of hospital services.

Thus, in order to explain present allocation practices in the health services industry, it is necessary to discard the type of model premised by profit-maximizing producers. A behavioral model must be specified which will somehow simulate "who is maximizing what" in a hospital. Further, the variables dealt with in the maximization process must be specified (that is, the independent variables). This task is undertaken in Chapter III.

CHAPTER III

SPECIFICATION OF THE MODEL

MEANINGFUL THEOREMS

In the Samuelson tradition,[13] meaningful theorems are defined as those which can conceivably be refuted (if only under ideal conditions). Meaningful theorems derive from two general types of hypotheses:

(a) those in which the conditions of equilibrium are tantamount to the maximization or minimization of some magnitude, and

(b) those in which the dynamic properties of the system are specified and the hypothesis is made that the system is in "stable" equilibrium or motion.

The latter hypothesis involves the use of the "correspondence principle", which explores the intimacy of the relationship between the stability problem and the derivation of fruitful theorems in comparative statics.

It is intended, in this analysis, to derive meaningful theorems from the former type of hypothesis. The comparative static method will be used to derive these theorems.

THE COMPARATIVE STATIC METHOD

The method of comparative statics involves the designation of a set of variables for which solution values can be derived. Imposed on the variables are certain re-

strictions in the form of mathematical equations which, when solved, will yield equilibrium values for the variables given a set of parameters. The parameters (whose values locate the system in space) are defined when a closure is selected for the system.

The theoretical system under discussion will have as parameters the government supply programme and government expenditures on hospital services for any given hospital. It is of no small importance to realize that one parameter change, through interactions throughout the system, will result in an entirely new set of solution values for the variables. Comparative statics, then, involves the investigation of the changes in the solution values of variables resulting from changes in parameters.

FORMAL SPECIFICATION[14]

It is postulated that "hospital administrators" adjust the number of cases treated (N), duration of stay (S) and quality of care (Q) in a way consistent with the maximations of a utility function:

(1) $U = U\ (N,S,Q)$.

The utility function is assumed to be cardinal and separable by a logarithmic transformation. To illustrate, the separability assumption suggests the utility function to be of a form such as

(2) $U - S^{\alpha}\ N^{\beta}\ Q^{\delta}$

so that taking logarithims yields

(3) $\log U - \alpha \log S + \beta \log N + \delta \log Q$

Thus, there is no problem identifying the separate effects of each variable. In addition this assumption implies no cross effects between elasticities taken with respect to utility.[15]

Within the relevant range (defined by a set of constraints to be introduced) the marginal utilities $\frac{\partial U}{\partial S}$, $\frac{\partial U}{\partial N}$, $\frac{\partial U}{\partial Q}$, are assumed to be positive while the second order partials are negative (i.e. positive but diminishing marginal utilities). Further, it is assumed that the cross partials $\frac{\partial^2 U}{\partial S \partial N}$, $\frac{\partial^2 U}{\partial S \partial Q}$, $\frac{\partial^2 U}{\partial Q \partial N}$ are also positive and, by Young's Theorem,[16] $\frac{\partial^2 U}{\partial S \partial N} = \frac{\partial^2 U}{\partial N \partial S}$, $\frac{\partial^2 U}{\partial S \partial Q} = \frac{\partial^2 U}{\partial Q \partial S}$, $\frac{\partial^2 U}{\partial Q \partial N} = \frac{\partial^2 U}{\partial N \partial Q}$.

This latter condition ensures the Bordered Hessian will in fact be symmetric (the Hessian is bordered due to the constrained nature of the present maximization).

The first constraint is of the form

(4) $B = \frac{NS}{365\ R}$,

where B is the number of beds available in a given hospital, N and S are as before, and R is the proportional rate of occupancy and is fixed for a given hospital.

The second constraint is a hospital budget constraint:

(5) $E = N\ S\ D$

where D is a constant elasticity cost function.[17]

(6) $D = A\,S^{\alpha}\,Q^{\beta}$, which implies $E = ANS^{\alpha+1}\,Q^{\beta}$.

A is a constant, S is duration of stay, Q is quality of care and α and β are parameters. In the cost function it is assumed that the elasticity of cost per patient day with respect to duration of stay is negative and very small.[18] That is, average cost per patient day actually declines as duration of stay increases.

Verbally, a given hospital must operate within the bounds specified by its budget allocation from the government. Average cost per patient day is defined by the specification in (6). (5) states that total expenditures for a given year cannot exceed E, the budget allocation. Thus, "administrators" have their freedom restricted to varying N, S and Q such that the equalities of (5) and (6) hold.

Quality, it should be pointed out, is a catch-all term to denote the general level of amenities provided to a patient. That is, it is a residual variable containing those components of the utility function other than N and S.

Formally, the "hospital administrator" is assumed to maximize the constrained function:

(7) $U^{*} = U\,(N,S,Q) + \lambda_1\,\left(\frac{NS}{365\;R} - B\right) + \lambda_2\,(NAS^{\alpha+1}\,Q^{\beta} - E).$

Matters can be facilitiated by using lower case letters to

represent the logarithmic transformation of the original variable:[19]

(8) $$u^* = u(n,s,q,) + \mu_1 \ (n + s - \log 365 \ \underline{=} \ r - b) + \mu_2 \ [n + (\alpha + 1)s + \beta q + a - e].$$

First order conditions for maximization of the Lagrangean are then:

(9)
$$\frac{\partial u^*}{\partial n} = u_n + \mu_1 + \mu_2 = 0$$
$$\frac{\partial u^*}{\partial s} = u_s + \mu_1 + (1 + \alpha)\ \mu_2 = 0$$
$$\frac{\partial u^*}{\partial q} = u_q + \beta\mu_2 \ = 0$$
$$\frac{\partial u^*}{\partial \mu_1} = n + s - r - \log 365 - b = 0$$
$$\frac{\partial u^*}{\partial \mu_2} = n + (\alpha + 1)s + \beta q + a - e = 0.$$

Assuming the equilibrium conditions to be fulfilled, the system can be disturbed by arbitrary changes in parameters. This can be formulated into a system in which the variables are now the changes in the variables concomitant with the changed parameters:

(10)
$$u_{nn}dn + d\mu_1 + d\mu_2 = 0$$
$$u_{ss}ds + d\mu_1 + (1 + \alpha)\ d\mu_2 = 0$$
$$u_{qq}dq + \beta d\mu_2 = 0$$
$$dn + ds = db$$
$$dn + (\alpha + 1)\ ds + \beta dq = de.$$

This is written more concisely in matrix form:

(11)
$$\begin{bmatrix} U_{nn} & 0 & 0 & 1 & 1 \\ 0 & U_{ss} & 0 & 1 & 1+a \\ 0 & 0 & U_{qq} & 0 & \beta \\ 1 & 1 & 0 & 0 & 0 \\ 1 & 1+\alpha & \beta & 0 & 0 \end{bmatrix} \begin{bmatrix} dn \\ ds \\ dq \\ d\mu_1 \\ d\mu_2 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ db \\ de \end{bmatrix}$$

Recalling the standard linear algebraic results and denoting the Bordered Hessian by H and element i, j of its inverse by H^{ij} the solution can be written

(12)
$$\begin{bmatrix} dn \\ ds \\ dq \\ d\mu_1 \\ d\mu_2 \end{bmatrix} = H^{-1} \begin{bmatrix} 0 \\ 0 \\ 0 \\ db \\ de \end{bmatrix},$$

so that dn and ds are

(13) $dn = H^{14}db + H^{15}\,de$

(14) $ds = H^{24}db + H^{25}\,de$

where, for example, $H^{15} = \dfrac{/C_{51}/}{/A/}$.

$/c_{51}/$ here is the cofactor of the element appearing in the fifth row and first column of the matrix of coefficients $[A_{ij}]$. /A/ is the determinant of the matrix of coefficients (see (11) above).

The elasticity of the number of cases treated with respect to the number of beds available can be expressed as

(15) $\frac{dn}{db} = H^{14} = H^{15} \quad (\frac{de}{db})$,

where $\frac{de}{db}$ is the elasticity of budget expenditures with respect to the number of beds available.

The mean stay elasticity is, similarily,

(16) $\frac{ds}{db} = H^{24} + H^{24} \ (\frac{de}{db})$.

Calculating and simplifying the elements of the inverse matrix yields[20]

(17) $\frac{dn}{db} = \left(\beta^2 \ u_{ss} + \alpha \ (1 - \frac{de}{db}) \ u_{qq} + \alpha^2 \ u_{qq}\right) \ |H|^{-1}$

(18) $\frac{ds}{db} = \left(\beta^2 \ u_{nn} - \alpha \ (1 - \frac{de}{db}) \ u_{qq}\right) \ |H|^{-1}$

FORMULATION OF THE BASIC HYPOTHESES

Ideally, it would be desirable to employ what is referred to by Samuelson[21] as "a calculus of qualitative relations" to deduce a set of testable hypotheses from the model. That is, from known signs of certain partial derivatives, be able to deduce the direction of change in the variables of interest associated with changes in parameters.

In equation (17) and (18) it is interesting to predict the sign of dn and ds, given the direction of change indicated by db. As it turns out, sign predictions can be made from the derivatives in question, but they rely on economic intuition as well as known signs of partial derivatives.

From (17) the following sign configuration emerges:

$$\frac{dn}{db} = \left(\beta^2 u_{ss}^{(-)} + \alpha(1 - \frac{de}{db})u_{qq} + \alpha^2 u_{qq}^{(-)}\right) \quad \overset{(-)}{|H|}{}^{-1}.$$

The expressions u_{qq}, u_{nn} and u_{ss} represent the rates of change of certain elasticities resulting from infinitisemally small changes in the indicated variable. It is reasonable to suppose that these changes are negative, since increments in the variables would tend to create progressively smaller utility responsiveness. That is, one would tend to approach thresholds beyond which utility responds very little to increases in the respective variable. $/H/^{-1}$ is negative by the second order conditions for the maximization which are assumed to hold. It remains to anticipate the sign of $\alpha(1 - \frac{de}{db})\ u_{qq}$. $\frac{de}{db}$ is a measure of the extent to which the funds allocated to a hospital change in proportion to the number of beds available. Since government authorities presumably attempt to provide the same budget per available bed, one would expect $\frac{de}{db}$ to be approximately unity. Accepting this, the term $\alpha(1 - \frac{de}{db})\ u_{qq}$ tends to be around zero and consequently can be disregarded.

Applying analogous reasoning for (18), the signs of the derivatives become:

(19) $\frac{dn}{db}$ 0

(20 $\frac{ds}{db}$ 0.

These are not really breathtaking since one would

not expect, for example, an increase in bed availability to reduce either mean stay or cases treated.

A more subtle hypothesis can, however, be derived from the model. There is a reasonable "a priori" justification for formulating the following hypothesis: the elasticity of cases treated with respect to bed availability per capita is greater than the elasticity of mean stay with respect to bed availability per capita.

Intuitively, this asserts that the relevant decision-makers will tend to increase the numbers of patients they admit in response to a bed surplus relatively more than they increase lengths of stays of hospitalized patients. The following assertions loan credence to this hypothesis:[22]

(a) the hospital physician's feeling of greater responsibility for the patient in his own personal care than for people who are waiting for admission,

(b) the desire on the part of various types of medical people to "play it safe" and avert the risks associated with shorter lengths of stay,

(c) the influence of the patient himself on his length of stay, tending to make duration of stay less responsive to bed scarcity.

The first suggests that doctors whose patients are already in hospital will not greatly vary the patients' length of stay in response to bed scarcity. The second would mean that mean stays of patients are already relatively high (due to the risk-averting behavior of doctors). Thus, bed surpluses would not tend to increase patients' lengths of stay. The third is self-explanatory.

The conjecture has been made that

$$(21)\qquad \frac{dn}{db} > \frac{ds}{db}\,.$$

Necessary and sufficient conditions for $\frac{dn}{db} > \frac{ds}{db}$ are derived by substituting (17) and (18) into (21):

$$(22)\qquad \left(\beta^2 u_{ss} + \alpha(a - \frac{de}{db})u_{qq} + \alpha^2 u_{qq}\right) |H|^{-1} > \left(\beta^2 u_{nn} - \alpha(1 - \frac{de}{db})u_{qq}\right) |H|^{-1}$$

The maximization of the utility function implies $/H/^{-1}$ is negative to that

$$(23)\qquad \beta^2 u_{ss} + \alpha(1 - \frac{de}{db})u_{qq} + \alpha^2 u_{qq} < \beta^2 u_{nn} - \alpha(1-\frac{de}{db})u_{qq}$$

$$(24)\qquad \beta^2 u_{ss} + \alpha(1 - \frac{de}{db})u_{qq} + \alpha(1 - \frac{de}{db})u_{qq} + \alpha^2 u_{qq} < \beta^2 u_{nn}$$

$$(25)\qquad \beta^2 u_{ss} + \alpha u_{qq}\left(2(1 - \frac{de}{db}) + \alpha\right) < \beta^2 u_{nn}$$

$$(26)\qquad 2\alpha\left\{\left(1 - \frac{de}{db}\right) + 0.5\alpha \quad u_{qq}\right\} < \beta^2 \quad (u_{nn} - u_{ss})\ .$$

As before it cannot be proven that (26) will hold, since known sign configurations do not yield an unambiguous answer. It is possible, however, to deduce why one might expect (26) to be true.

α, it is recalled, is assumed negative and very small. $\frac{de}{db}$ is expected to be near unity. The second order partials u_{qq}, u_{nn} and u_{ss} are negative.

Given these assumptions, the expectation would follow that

$$(27) \quad 2\alpha \left(1 - \frac{de}{db}\right) + \alpha^2 (u_{qq}) < 0.$$

Since β^2 is positive, it remains only to justify the conjecture that $u_{nn} \geqq u_{ss}$. That is, the elasticity of utility with respect to duration of stay decreases at least as rapidly as the elasticity with respect to the number of cases. This result would be expected, since duration of stay for most patients is already such as to minimize relapses. Therefore, the only major source of utility gain is obtained through increases in the number of cases which are treated.

Thus, $\beta^2 (u_{nn} - u_{ss})$ is probably greater than zero and (26) would hold.

CHAPTER IV

THE ECONOMETRIC METHODOLOGY

THE ECONOMETRIC MODEL

The analysis of Chapter III was carried out in the deterministic environment characteristic of many theoretical models. If one were certain that all conceivable variables and relationships were specified, the thesis could have ended at that point. As a matter of practical fact, however, one may be sure that the specification is not entirely complete and that unincluded factors will tend to create observed disturbances from the model. Thus, in relating the model to the empirical world one must be ever-conscious of a stochastic component.

The technique used to relate the deterministic model to the empirical (and therefore stochastic) world will be linear regression analysis. The following assumptions are made with regard to the regression model:

(a) $Y_i = \alpha + \beta X_i + e_i$

(b) $E(ei) = 0$ for all i

(c) $E(ei\ ej) = \begin{cases} 0 & \text{for } i \neq j,\ j, 1, 2, \text{--}\ n \\ \sigma^2 & \text{for } i = j,\ \grave{}i,\ j = 1, 2\ \text{--}\ n \end{cases}$

(d) $E(X_i, ei) = 0$.

These assumptions are sufficient to ensure that the relevant estimators will be "best linear unbiased".

The use of regression analysis will also make it convenient to estimate elasticities directly in the form

of slope coefficients after the variables have been logarithmically transformed. Specifically, one can estimate

(1) $\log (S) = \hat{\alpha}_1 + \hat{\eta}_1 \log (A_i) + \log E_i$

(2) $\log (N) = \hat{\alpha}_2 + \hat{\eta}_2 \log (A_i) + \log E_i$

where S is mean stay, A is beds available per 1,000 population, N is cases treated per 1,000 population and E is the error term. Thus, the estimated elasticity of mean stay and elasticity of cases treated, with respect to per capita bed availability, will appear as $\hat{\eta}_1$ and $\hat{\eta}_2$ respectively.

Although the simple regression model will be sufficient to test the basic hypothesis derived in Chapter III, an extension to multiple regression analysis will permit other empirical questions to be answered. In particular:

(a) If beds are relatively scarce in a particular region, are there simply fewer cases treated or are the lengths of stay per treatment shorter?

(b) Are older or younger patients more affected by the scarcity of beds?

(c) Which types of patients - given certain diagnostic categories - are most affected?

TEMPORAL DIMENSIONS OF THE STUDY

The empirical analysis will be carried out on

cross-section data for the year 1968. Several factors influence the choice of cross-section data as opposed to time-series:

(a) In Alberta there has, over the past decade and a half, been a significant rural-urban drift. Time-series data would tend to be influenced by this trend and would therefore require very cautious handling.

(b) Technological change, over time, would tend to render as variable those influences which it is desirable to hold constant.

Cross-sectional data, on the other hand, ensures the relative constancy of such exogenous forces and should consequently produce more reliable estimates though consideration should be given to extraneous inter-hospital differences.

SPATIAL DIMENSIONS OF THE STUDY

The universe of discourse from a spatial standpoint is the province of Alberta. Sample points are derived from a set of regions wholly contained within the province. The term "region" is considered synonymous with a "hospital service area" so that the problem of defining a region reduces to that of defining a hospital service area. It should be noted that "hospital administration areas", as defined by the provincial government, are not necessarily similar in any way to those regions defined for the present

study.

The regions in this study were drawn without overlap, so that 85 to 90 percent of the actual users of the facility are included. There is, of course, no restriction on the hospital to be used by any particular Alberta resident so there occurs a slight inter-regional drifting of consumers. This type of drifting - inasmuch as it is between "rural" areas - should tend to cancel itself out. Another drift, of greater concern, is toward the larger urban hospitals which provide more sophisticated treatment facilities for some cases.[23] Significance tests are carried out to examine whether or not such a drift significantly affects the results.

Problems were also encountered in the case of such atypical hospitals as Jasper, Banff and Slave Lake, which tend to service a relatively large number of transient people, (skiers, oilworkers, etc.) Accordingly, these hospitals were removed from the sample.

In addition it was found virtually impossible to define service areas for certain city hospitals (whenever a centre had more than one hospital) since any attempt to appropriate population to hospitals in some proportion to hospital size would remove the variability in the supply variable. Clearly, good regression analysis requires a modicum of variability in the independent variables. Consequently, such hospitals were lumped into single

statistical units serving the relevant metropolitan areas.

AN EXTENSION OF THE ECONOMETRIC MODEL

As indicated in Chapter II (footnote 8) a primary concern is with the estimation of elasticities (responsiveness indices). Multiple regression on logarithmically transformed variables will facilitate the estimation of the relevant elasticities.[24] Elasticity of mean stay and elasticity of cases treated with respect to bed supply will be estimated for the aggregated data, by age categories, by diagnostic categories and by sex. Analysis of covariance (by the dummy variable method) will be incorporated into the model in order to test for significant variation between the categorical estimates.[25]

Two common methods of carrying out analysis of covariance tests are the Chow Test and the dummy variable method. The latter is to be preferred for several reasons:[26]

(a) If two regressions are different, the Chow Test will show they are different without specifying the source of the differences. The dummy variable approach clearly points out the source of the differences.

(b) In just one regression one can obtain all the necessary information, whereas the Chow Test is a multi-stage procedure.

Since two types of elasticities (mean stay and cases treated) are to be estimated, there will be two regression equations each time the data is categorized. The regression for the diagnostic categorization will assume the general form:

$$(1) \quad \log S_{ij} = \hat{\alpha}_{s1} + \hat{\alpha}_{s2}(D_2) + \hat{\alpha}_{s3}(D_3) + \ldots + \hat{\alpha}_{sd}(D_d) + \hat{\eta}_{s1} \log A_i + \hat{\eta}_{s2}(D_2) \log A_i + \ldots + \hat{\eta}_{sd}(D_d) \log A_i + \log E_{ij}$$

$$(2) \quad \log N_{ij} = \hat{\alpha}_{N1} + \hat{\alpha}_{N2}(D_2) + \ldots + \hat{\alpha}_{Nd}(D_d) + \hat{\eta}_{N1} \log A_i + \hat{\eta}_{N2}(D_2) \log A_i + \ldots + \hat{\eta}_{Nd}(D_d) \log A_i + \log E_{ij} .$$

NOTATION: $\hat{\alpha}_{s1}$ = intercept estimate for diagnostic category 1, where s refers to mean stay being the independent variable.

$\hat{\alpha}_{sj}$ = differential intercept estimate for category j = 2, 3 ... d, where d is the number of diagnostic categories.

$\hat{\eta}_{s1}$ = slope estimate for diagnostic category 1.

$\hat{\eta}_{sj}$ = differential slope estimate for diagnostic category j = 2, 3 ... d.

D_j = dummy variable used both additively and multiplicatively. D_j = 1 for observations in category j (j = 2, 3 ... d) and is zero elsewhere.

E_{ij} = error term for observation i and category j.[27]

N = number of cases treated per 1,000 population.

A = beds available per 1,000 population.

The terms "differential intercept estimate" and "differential slope estimate" will be made clear in one of the following illustrations.

For diagnostic category 1, the mean stay regression would read

(3) $\log S_{i1} = \hat{\alpha}_{s1} + \hat{\eta}_{s1} \log A_i.$

It should be noted that the other terms in equation (1) disappear because the dummy variables take on zero values for this diagnostic category. Thus, the estimated elasticity of mean stay with respect to per capita bed availability is $\hat{\eta}_{s1}$.

For diagnostic category 2 the regression would read[28]

(4) $\log S_{i2} = \hat{\alpha}_{s1} + \hat{\alpha}_{s2}(D_2) + \{\hat{\eta}_{s1} + \hat{\eta}_{s2}(D_2)\} \log A_i.$

Here the dummy variables 3, 4 ... d assume zero values while D_2 is unity. It is clear that to obtain the intercept and slope estimates for categories 2, 3 ... d it is necessary to add the coefficient on the relevant dummy variable to estimates for category 1. Thus, the coefficients on the dummy variables are referred to as

"differential estimates".

Insertion of the dummy variables permits the hypothesis

$$H_0: \eta_{s1} = \eta_{s2} = \ldots \eta_{sd} = 0$$

to be readily tested. This hypothesis is accepted if none of the estimated coefficients on the dummy variables are significantly greater than zero. If H_0 is accepted, it is concluded that a single regression across the pooled data is satisfactory.

If, on the other hand, the null hypothesis is rejected, it is concluded that a data categorization is desirable. Thus, running individual regressions for each of the categories explains significantly more of the variation in the dependent variable and provides a better elasticity estimate.

In addition, one might test whether or not the slope estimate for category 1 is significantly greater than zero. This would be a straighforward application of the t test for a given level of significance.

Exactly analogous procedures can be applied each time a different categorization scheme is imposed on the data. The number of dummy variables would always be one less than the number of categories under consideration. The dummies would be similarily used in both the additive and multiplicative form. Testing procedures, again, would be strictly analogous.

CHAPTER V

THE EMPIRICAL RESULTS

EMPIRICAL RESULTS OBTAINED FROM THE SIMPLE REGRESSION MODEL

In specifying the econometric model the first step entailed setting up the fundamental regression equations:

(1) $\log S_i = \hat{\alpha}_{si} + \hat{\eta}_s \log A_i + \log E_i$

(2) $\log N_i = \hat{\alpha}_{Ni} + \hat{\eta}_N \log A_i + \log E_i$

where the notation corresponds to that employed in Chapter IV.

The objective was to estimate the following elasticities:

(3) $\eta_s = \frac{ds}{dA} \cdot \frac{A}{S} = \frac{d \log S}{d \log A}$

(4) $\eta_N = \frac{dn}{dA} \cdot \frac{A}{S} = \frac{d \log N}{d \log A}$

where η_s is the elasticity of mean stay with respect to per capita bed availability and η_N is the correspon-ding cases-treated elasticity.

It should be noted that the elasticity of beds used is equal to the sum of the mean-stay and cases-treated elasticities. That is, beds used/1,000 population = (constant) (mean stay) (cases treated/1,000 population), so that

(5) $\log B - \log K + \log S + \log N.$

Taking the differential and dividing through by d log A:

(6) $$\frac{d \log B}{d \log A} = \frac{d \log S}{d \log A} + \frac{d \log N}{d \log A}$$

or

(7) $$\eta_B = \eta_S + \eta_N .$$

This simply means that (1) the beds-used elasticity is a measure of the total effect on bed use of a change in per capita bed availability; (2) the total effect on bed use can be broken down into two components -- that portion due to increased (or decreased) mean stay and that due to increased (or decreased) numbers of cases treated.

The elasticities, along with other relevant information, are recorded in Table I.

TABLE I

ELASTICITIES WITH RESPECT TO BED AVAILABILITY

	Estimate	t value	S.E.	d.f.	R^2
Mean-Stay Elasticity	0.103	2.03*	0.05	99	0.04
Cases-Treated Elasticity	0.593	8.12*	0.07	99	0.36
Beds-Used Elasticity	0.696				

* t value significant at 2.5 percent.

S.E. Standard Error

d.f. Degrees of Freedom

Recalling the three hypotheses of Chapter III

$$\left(\frac{d \log N}{d \log A} > 0, \frac{d \log S}{d \log A} > 0 \text{ and } \frac{d \log N}{d \log A} > \frac{d \log S}{d \log A} \right),$$

it will be noted that all three are statistically verified in Table I. Both the mean-stay elasticity and the cases-treated elasticity are significantly greater than zero, based on a one-tail test for a 2.5 percent significance level. Further, the cases-treated elasticity is more than five times as large as the mean-stay elasticity.[29]

The results compare favorably with those of Feldstein for a sample of British hospitals.[30] Feldstein estimates the mean-stay elasticity to be 0.365, the cases-treated elasticity to be 0.580 and the beds-used elasticity to be 0.947. The results of the present study suggest that a 10 percent increase (decrease) in per capita bed availability leads to a 6.96 percent increase (decrease) in per capita bed usage. In Feldstein's model the increase in bed usage is a high 9.47 percent. These responsiveness indices for bed usage can be broken up into a responsiveness index for mean stay and a responsiveness index for cases treated. In this study, there will be an increase of 5.93 percent in cases treated, closely matched by a 5.8 percent increase for the British case. The basic difference between the two beds-used elasticities is a result of differing responsiveness indices for mean stay. In the Alberta system a 10 percent increase in per capita bed availability leads to a 1.03 percent increase in mean stay, whereas the corresponding figure

estimated by Feldstein is 3.65 percent.

Feldstein notes with some dismay that his cases-treated elasticity is 50 percent greater than his mean-stay elasticity. His dismay appears to find its origins in the idea that a high cases-treated elasticity suggests that some people in "need" of hospitalization may not receive it if beds are in relatively short supply. Implicit here is the belief that a method exists for clearly delineating "need" for admission to hospital.

TABLE II

PER CAPITA (PER 1,000) BED AVAILABILITY IN CANADA BY PROVINCE

PROVINCE	BEDS AVAILABLE PER 1,000 POPULATION
Newfoundland	6.03
Prince Edward Island	6.86
Nova Scotia	6.77
New Brunswick	7.33
Quebec	6.86
Ontario	7.23
Manitoba	7.11
Saskatchewan	7.81
Alberta	9.54
British Columbia	7.10

In a hospital system such as Alberta's, where bed supply per capita is reportedly the highest in Canada, (as indicated by Table II) there is the distinct possibility of excess capacity. This is reinforced by the fact that the beds-used elasticity in Alberta is only 0.696 compared with that of 0.947 in Britain. Thus, there ap-

pears to be substantially more demand for additional beds in Britain than is the case in Alberta. As further support for the excess capacity idea, it is noted that the average utilization rate in Alberta is only 65 percent, as opposed to 77 percent for the hospitals in Feldstein's sample. Finally, bed availability per capita averages 5.42 in Feldstein's study as opposed to 9.54 in Alberta.

Given an excess capacity situation in the system[31] and the behavioral model of Chapter III, there emerges a very reasonable explanation for the elasticities. "Administrators",[32] in the process of maximizing utility, will tend to react to excess capacity by hospitalizing patients whose "need" for hospitalization can only be considered marginal. The term "marginal" is taken to mean that certain patients are hospitalized who would not otherwise be if beds were not so readily available. The marginal case would also be one for which treatment can be administered outside of the hospital. This is also consistent with profit-maximization[33] by medical practitioners. A physician (to quote Evans and Walker[34]) "...will view a hospital as free capital and labor which enable him to increase his output and productivity. Prices are fixed in the short-run; complimentary factors of production are free; so he maximizes output per unit of (his own) labor."

Mean stays, however, would probably be relatively high already - given the relative excess capacity - so

that "packing" by increased mean stays would be minimal.[35] Thus, utilization rates and cases treated can be simultaneously stimulated by admitting more marginal cases when bed surpluses prevail. It should be noted that large numbers of cases treated per se may increase hospital prestige but maintenance of a reasonably high utilization rate may be a necessity in order to present a facade of efficiency, maintain budget appropriations and, more serious, to fend off the threat of closure.[36]

In a system characterized by relatively great demand pressure (the British system) the need and/or desire to "pack" in order to maintain utilization rates becomes of marginal value. Although it may be true that the occasional bottlenecks are present in the Alberta hospital system, the assertion that patients actually in "need" of hospital care are being refused must be discarded.[37] The fact of the cases-treated elasticity being substantially greater than the mean-stay elasticity appears to be largely explainable by a behavioral tendency, in the system as a whole, to respond to bed surpluses by treating realtively more cases of marginal "need".

ELASTICITIES WITH RESPECT TO BEDS USED

The simple regression model was also used to obtain a set of elasticities for which beds used per capita is the explanatory variable. The results appear in Table III.

TABLE III

ELASTICITIES WITH RESPECT TO BEDS USED

	Estimate	t	S.E.	d.f.	R^2
Mean-Stay Elasticity	0.076	1.63*	0.05	99	0.03
Cases-Treated Elasticity	0.664	12.47**	0.05	99	0.6

* Significant at 10 percent in one tail
** Significant at 2.5 percent in one tail

It is noted that the elasticities of 0.076 and 0.664 for mean stay and cases treated, respectively, do not differ appreciably from the previous estimates set out in Table I.

For purposes of this study, however, the beds-available variable is to be preferred to the beds-used variable.[38] Beds used per capita tends to not only reflect differences in bed supply per se, but also the efficiency with which this existing supply is utilized.[39] It is argued that the use of this variable would tend to obscure the sought-after relationship between physical bed supply and the utilization variables (mean stay and cases treated). Thus, the remainder of the study will treat beds available per capita as the supply variable.

RURAL - URBAN RESULTS

In Chapter IV, concern was expressed over whether the drift to urban hospitals for certain types of treatment would have a significant effect on the elasticity estimates.

To test for this effect the hypothesis was set up that there is no difference between rural and urban estimates. In an attempt to refute this hypothesis, a rural-urban dummy variable was incorporated into an analysis of covariance framework. Following the specification of Chapter IV the regressions:[40]

(1) $\log S_i = \hat{\alpha}_{S1} + \{\hat{\eta}_{S1} + \hat{\eta}_{S2}(D)\} \log A_i + \log E_i$

(2) $\log N_i = \hat{\alpha}_{N1} + \{\hat{\eta}_{N1} + \hat{\eta}_{N2}(D)\} \log A_i + \log E_i$

were set up. The categorical variable, in this case, equals one for urban hospitals and zero elsewhere. The hypothesis to be tested can be reduced to whether or not the differential slope estimates are significantly different from zero. If they are, it is concluded that categorized estimates are preferable. These estimates are $\hat{\eta}_{S1}$ and $\hat{\eta}_{N1}$ for rural hospitals and $(\hat{\eta}_{S1} + \hat{\eta}_{S2})$ and $(\hat{\eta}_{N1} + \hat{\eta}_{N2})$ for urban hospitals. The results are recorded in Table IV.

The results indicate that there is not a significant difference between rural and urban elasticity estimates. Since statistics should not be considered absolute, it is noted that a significance level of 12 percent would have led to rejection of the null hypothesis regarding equality of mean-stay elasticities. In this case the revised estimates would then indicate a mean-stay elasticity of 2.11 for urban, and 0.10 for rural, hospitals.

TABLE IV

DUMMY VARIABLE ANALYSIS OF COVARIANCE FOR RURAL-URBAN CATEGORIZATION

Dependent Variable	Rural Elasticity Estimate	t Value	S. E.	Urban Differential	t Value	S. E.	d.f.	R^2
Mean Stay	0.0995	2.026	0.05	2.013	1.59*	1.26	99	0.12
Cases Treated	0.595	8.08	0.073	-1.002	-0.53*	1.99	99	0.41

* t values not significant at 10 percent

It is useful to attempt to provide an explanation for the large differences in urban-rural estimates (that is, accept a 12 percent probability level and reject the null hypothesis.) Casual empiricism suggests that there is relatively greater demand pressure on urban, as opposed to rural, hospitals. It is noted that many rural hospitals were constructed to meet demands imposed on a particular region some years ago. Over the past several decades there has been a notable rural-urban drift, particularly in the Prairie Provinces. This would have the effect of shifting the individual demand curves of many rural hospitals in a downward direction, a trend supported by the observation that the utilization rates for rural hospitals are around 65 percent as compared with 73 percent for urban hospitals. Additional support is obtained by noting that there are approximately 7.76 beds per capita in the rural vis-a-vis 7.02 bed per capita in urban hospitals.

Given two sets of hospitals characterized by differing relative demand pressures, one would expect a higher cases-treated and a lower mean-stay elasticity for the groups characterized by lower demand pressure. The results obtained by establishing separate elasticity estimates for the rural-urban categories supports this argument. The urban results are approximately 2.1 and 0.6 for mean-stay and cases-treated, respectively, whereas the corresponding rural results are approximately 0.1 and 0.6.

It is important to note, from this discussion, that one must be very careful in interpreting these results. One cannot simply accept the null hypothesis, yet the results are not decisive enought to reject it conclusively. Clearly, there is a need for a closer examination of rural versus urban hospital.

ELASTICITY ESTIMATES CATEGORIZED BY SEX

The model is set up in a manner exactly analagous to the specification for the rural-urban classification, with the exception that the categorical variable now takes on values of unity for females and zero for males. The relevant results are tabulated in Table V.

Disregarding the insignificant differentials for a moment, the cases-treated elasticities of 0.652 for males and 0.538 for females compare favorably with Feldstein's estimates of 0.638 for males and 0.523 for females.[41] The mean-stay elasticities, however, are greatly divergent. Feldstein obtains 0.409 for males and 0.351 for females, as compared with the present estimates of 0.116 and 0.069 respectively. These results are explainable when one considers the differing demand pressures on the British and Alberta hospital systems. It was noted earlier in this chapter that Feldstein's beds-used elasticity for the whole system was 0.947. This indicates, in general, that a 10 percent increase in bed availability generates a 9.47 percent increase in beds used per capita.

TABLE V

ELASTICITIES WITH RESPECT TO BED AVAILABILITY BY SEX

Dependent Variable	Male Estimate	t	S.E.	Female Differential	t	S.E.	d.f.	R^2
Mean Stay	0.116	2.12	0.055	-0.047	-0.61*	0.08	199	0.04
Cases Treated	0.652	8.57	0.076	-0.114	-1.06*	-1.06	199	0.04

* Not significant at 20 percent.

In the Alberta system a similar proportionate increase in bed availability would result in only a 6.96 percent increase in per capita bed usage. It appears clear, then, that the British system studied by Feldstein is characterized by greater demand pressure than the present system. Following the reasoning of earlier sections, one would not be surprised at the higher mean-stay elasticities in the relevant part of the British system.

It is worth noting that, although Feldstein obtains numerous categorical estimates of elasticities, he performs no tests for significant differences between them.[42] Male-female elasticity differentials in the present study, for example, are substantially greater than the differentials in Feldstein's estimates, yet do not differ to a significant extent. (Although no positive assertion can be made, it is highly questionable whether Feldstein's estimates differ). The general conclusion of this section, then, is that a male-female categorization, at this level of aggregation, is not warranted.

ELASTICITY ESTIMATES CATEGORIZED BY AGE GROUP

The multiple regression model was again employed to assess the significance of estimating separate elasticities for different age groups. Since give age groups were delineated, four dummy variables were needed, one for each age group except the 0-to-4 year olds.

The results, recorded in Table VI, indicate that mean-stay elasticities do not differ significantly, using a two-tailed test at 10 percent. Relaxing one's tolerance of type I errors to 20 percent, however, permits acceptance of a higher elasticity (0.06 + 0.14 = 0.2) for the oldest group. This, of course, suggests that older patients tend to have longer mean stays in regions of greater per capita bed supply.

The null hypothesis -- that all cases-treated elasticities are, for statistical purposes, the same -- is rejected for a 10 percent level of significance. This indicates the need for a categorization of patients by age into groups whose cases-treated and mean-stay elasticities are similar. The approach taken to this grouping was to form one group of elasticities for which the t values indicated a significant difference from the base group for a 10 per cent significance level. The next group comprised those elasticities which were significantly different only when the significance level was dropped to 20 percent. The third group contained those elasticities which were not significantly different at either of the above levels. The regrouped elasticities appear in Table VII.

An examination of Table VII indicates that the 65-and-over group has the highest elasticities (both cases-treated and mean-stay) of all age categories. With regard

TABLE VI

ANALYSIS OF COVARIANCE (DUMMY VARIABLE METHOD)
BY AGE GROUP

	Estimate 0 - 4 Yrs.	t	S.E.	Differential 5-14 Yrs.	t	S.E.	Differential 15-24 Yrs.	t	S.E.		
MEAN STAY	0.06	0.87	0.07	0.032	0.33	0.096	-0.082	-0.85	0.096		
ELASTICITIES AND DIFFERENTIALS	Differential 25-44 Yrs.	t	S.E.	Differential 45-64 Yrs.	t	S.E.	Differential 65 + Yrs.	t	S.E.	d.f.	R^2
	0.031	0.32	0.096	0.026	0.27	0.096	0.14	1.49	0.097	593	.64

	Estimate 0 - 4 Yrs.	t	S.E.	Differential 5-14 Yrs.	t	S.E.	Differential 15-24 Yrs.	t	S.E.		
CASES TREATED	0.360	3.1*	0.12	0.210	1.29	0.17	-0.0001	-0.01	0.17		
ELASTICITIES AND DIFFERENTIALS	Differential 25-44 Yrs.	t	S.E.	Differential 45-64 Yrs.	t	S.E.	Differential 65 + Yrs.	t	S.E.	d.f.	R^2
	0.078	0.47	0.17	0.480	2.88*	0.17	0.583	3.18*	0.17	593	.2

t = t value
S.E. = Standard Error
d.f. = Degree of Freedom

R^2 = Coefficient of Determination
* = t Value Significant For a Two-Tail Test At a 10 percent Significance Level

TABLE VII

REGROUPED ELASTICITIES OF DIFFERENT AGE GROUPS

	CASES-TREATED ELASTICITY		MEAN-STAY ELASTICITY	
GROUP I	0-4 YEARS	0.36	0-4 YEARS	0.06
	15-24 YEARS	0.36	5-14 YEARS	0.09
	25-44 YEARS	0.36	15-24 YEARS	-0.02
			25-44 YEARS	0.09
			45-64 YEARS	0.09
GROUP II	5-14 YEARS	0.57	65 + YEARS	0.20
GROUP III	45-64 YEARS	0.84		
	65 + YEARS	0.94		

to the cases-treated elasticities, both the 45-64 and 65+ group have very similar and very high responsiveness indices. This suggests that as one moves across regions[43] there will be stronger tendencies to hospitalize older patients in areas of higher per capita bed supply than in areas of lower per capita bed supply. Although it is not as strong, there is a similar tendency to increased lengths of stay for the oldest group in regions of relatively great per capita bed supply.

The adolescent group (5-14 years) has an elasticity for cases treated which is significantly greater than that for 0-4 year olds when the significance level is dropped to 20 percent. This is perhaps a reflection of a tendency for adolescent diseases to be less acute than

the type of diseases more strongly associated with the Group I age category.

In order to gain insight into the responsiveness of total bed usage by age group it is necessary to make use of the fact that the beds-used elasticity is the sum of the mean-stay and cases-treated elasticity. Table VIII records beds-used elasticities for the various age groups.

TABLE VIII

BEDS-USED ELASTICITIES BY AGE GROUPS

AGE GROUP	ELASTICITY
0 - 4 YEARS	0.42
5 - 14 YEARS	0.66
15 - 24 YEARS	0.34
25 - 44 YEARS	0.45
45 - 64 YEARS	0.93
65 + YEARS	1.09

Table VIII reveals an aggregative tendency for areas of relatively large per capita bed supply to permit relatively more bed use by patients in the older groups. In the 65 and over group a 10 percent increase (decrease) in per capita bed supply induces, on the average, a 10.9 percent increase (decrease) in per capita bed usage by this group.

It must be noticed that the relationships indicated above cannot be conclusively extended to any particular region. The elasticities describe responsiveness patterns

in a statistically representative hospital, and therefore hold only for the system represented. Clearly, there may be some regions where the results are strictly inapplicable. The next step, before any decisive micro-policy statements can be made, is to extend the analysis so that elasticities for particular regions may be derived.

The results can be related to the purported tendency to hospitalize cases of a marginally serious nature when beds are in abundance. The estimates indicate those age groups for which hospitalization and lengths of stay tend to vary with bed availability. In consequence, it is possible to identify the age groups for which "need" for hospitalization tends to be marginal.

ELASTICITY ESTIMATES BY DIAGNOSTIC CATEGORY

The last and most horrendous task was the application of the dummy variable method to the analysis of covariance for selected diagnostic categories. The multiple regression model was set up incorporating two equations (one for mean stay and one for cases treated) and 22 diagnostic categories (i.e., 21 dummy variables). Table IX presents the results in detail.

The fundamental hypothesis, that all mean-stay elasticities are the same and that all cases-treated elasticities are the same, is rejected for both the 10 and 20 percent level of significance. Thus one can con-

clude that a breakdown of elasticities by diagnostic category is desirable.

It will be noted that a number of the mean-stay elasticities appear to be negative.[44] It is an interesting exercise to attempt to establish an argument that would seemingly provide a possible basis for negative elasticity values. It is suggested that the sample itself may contain certain non-random patterns which tend to create the observed result. Specifically, there appears to be a tendency for larger per capita bed availability observations to be associated with smaller, more poorly equipped hospitals. This is a manifestation of the fact that rural hospitals tend to be smaller and more poorly equipped, while simultaneously having higher per capita bed availability. The converse is true of urban hospitals, so that as one moves across regions from those of low per capita bed availability to those of higher bed availability, there is a tendency to move from better-equipped and larger urban hospitals to smaller, more poorly-equipped, rural hospitals. In such rural hospitals, however, there may be a tendency to admit patients for examination and then refer them to a larger urban hospital for treatment. This would tend to create, for certain diagnostic categories, the appearance of a lower mean stay in rural regions, and could produce a negative elasticity.

TABLE IX

ELASTICITIES BY SELECTED DIAGNOSTIC CATEGORIES

DIAGNOSTIC CATEGORY	MEAN-STAY ELASTICITY ESTIMATE	DIFFER-ENTIAL ESTIMATE	S.E.	t VALUE
Other infective and parasitic diseases	-0.127	--	0.103	-1.23
Malignant neoplasms	-0.027	0.0999	0.145	0.69
Benign neoplasms	-0.122	0.0496	0.146	-0.34
Allergic, endocrine system, metabolic and nutritional diseases	-0.013	0.1142	0.145	0.79
Diseases of the ear and mastoid	0.108	0.2352	0.146	1.62*
Disease of the circulatory system	0.046	0.1731	0.145	1.19
Disease of the respiratory system	0.068	0.1949	0.145	1.34*
Disease of the digestive system	-0.043	0.0841	0.145	0.58
Disease of the urinary system	-0.039	0.0881	0.145	0.61
Diseases of the genital system (including hyperplasia of prostate)	0.016	0.1435	0.145	0.99
Diseases of the skin and cellular tissue	0.138	0.2653	0.146	1.82**
Diseases of bones and organs of movement	-0.023	0.1040	0.145	0.72
Diabetes mellitus	-0.086	0.0407	0.145	0.28
Other allergic, endocrine, metabolic and nutritional diseases	-0.075	0.0524	0.145	0.36
Acute upper respiratory infections	-0.064	0.0626	0.145	0.43
Pneumonia	0.062	0.1897	0.145	1.31*
Arteriosclerotic and degenerative heart diseases	0.029	0.1558	0.145	1.07
Other diseases of the heart	0.106	0.2335	0.146	1.60*
Other diseases of the respiratory system	0.089	0.2156	0.147	1.47
Appendicitis	-0.032	0.0954	0.154	0.62
Other diseases of the digestive system	-0.020	0.1069	0.146	0.73
Bronchitis	0.039	0.1661	0.145	1.14

(continued)

TABLE IX (continued)

DIAGNOSTIC CATEGORY	CASES TREATED ELASTICITY	DIFFER- ENTIAL ESTIMATE	S.E.	t VALUE	BEDS-USED ELASTICITY
Other infective and parasitic diseases	0.663	--	0.105	4.03*	0.536
Malignant neoplasms	0.581	-0.082	0.231	-0.35	0.554
Benign neoplasms	0.114	-0.549	0.233	-2.36**	-0.008
Allergic, endocrine system, metabolic and nutritional diseases	0.836	0.173	0.231	0.75	0.823
Diseases of the ear and mastoid	1.142	0.479	0.231	2.07**	1.250
Diseases of the circulatory system	0.734	0.071	0.231	0.31	0.780
Diseases of the respiratory system	0.762	0.099	0.231	0.43	0.830
Diseases of the digestive system	0.545	-0.118	0.231	-0.51	0.502
Diseases of the urinary system	0.827	0.164	0.231	0.71	0.788
Diseases of the genital system (including hyperplasia of prostate)	0.519	-0.144	0.231	-0.62	0.535
Diseases of the skin and cellular tissue	0.719	0.056	0.232	0.24	0.857
Diseases of bones and organs of movement	0.191	0.256	0.231	1.11	0.896
Diabetes mellitus	0.854	0.191	0.231	0.83	0.768
Other allergic, endocrine, metabolic and nutritional diseases	0.815	0.152	0.231	0.66	0.740
Acute upper respiratory infections	1.021	0.258	0.231	1.55*	0.957
Pneumonia	0.532	-0.131	0.231	-0.57	0.594
Bronchitis	0.790	0.127	0.231	0.55	0.829
Arteriosclerotic and degenerative heart diseases	0.614	-0.049	0.231	-0.21	0.643
Other diseases of the heart	0.716	0.053	0.233	0.23	0.822
Other diseases of the respiratory system	0.812	0.149	0.234	0.64	0.901
Appendicitis	0.407	-0.245	0.245	-1.05	0.375
Other diseases of the digestive system	0.484	-0.179	0.232	-0.07	0.464

degrees of freedom for mean-stay equation .. 2,183 * significant at 20 percent in two-tailed test
degrees of freedom for cases-treated equation .. 2,183 **significant at 10 percent in two-tailed test

This explanation, clearly, is not intended to be conclusive, but is merely offered as a possibility for further research and discussion. What is needed here is a more elaborate model, perhaps utilizing among others the knowledge of specially trained medical personnel.

From the table it is possible to break out a total index of the responsiveness of bed use to per capita supply with a further breakout to indicate how much of the change in bed usage is attributable to varying mean stays and how much to varying cases treated. In the case of diseases of the ear and mastoid, for example, a 10 percent increase in per capita bed availability will induce a 12.5 percent increase in per capita bed usage by victims of such ailments in the "typical" hospital in the system. This can be broken out into an increase in cases treated of this type of 11.42 percent and an increase in mean stay of 1.08 percent. At the other extreme it is noted that a 10 percent increase (decrease) in per capita bed availability induces virtually no change in bed usage by victims of benign neoplasms.

Generally speaking, there are instances of what a layman might label appropriate elasticities and inappropriate elasticities. Appendicitis, which one expects to demand immediate attention in most cases, has an appropriately low total bed-use elasticity of 0.375. This is broken into a mean-stay elasticity of nearly zero and a

cases-treated elasticity of 0.407. Diseases of the ear and mastoid, on the other hand, has a fairly high bed usage elasticity of 1.25. Both the mean-stay elasticity and cases-treated elasticity are relatively high at 0.108 and 1.142, respectively.

Examples of what one might consider inappropriate elasticities[45] are those for malignant neoplasms and arteriosclerotic and degenerative heart disease. The bed-use elasticity for the former is 0.554, which is compared with a mean-stay elasticity of -0.027 and a cases-treated elasticity of 0.581. In the latter case, the bed-use elasticity is 0.643 and is broken down into a mean-stay elasticity of 0.029 and a cases-treated elasticity of 0.614.

It would be unwise and inappropriate to offer any behavioral explanations of the individual elasticity values, since, to quote Feldstein:[46] "To do so properly, we should have to develop a complex theory of medical admissions and treatment decisions based on the factors that motivate patients to seek care and the way in which doctors diagnose and treat each type of disease."

CHAPTER VI

SUMMARY AND CONCLUSIONS

SUMMARY

It was established in Chapter II that the allocation of scarce resources in the area of hospital services is not achieved by the price mechanism. In consequence, there was no reason to believe that the allocations would reflect economic opportunity costs. The fact that inefficiency is a problem is reflected by the statement of Evans and Walker:[47]

> "Canadian health expenditures have been increasing at rates of between 10 and 15 percent for the past decade and in recent years have begun to accelerate. ...At the same time it is difficult to find evidence that Canadians are deriving any greater benefits from the industry in terms of increased health, well-being or productivity."

Hospitals being nonprofit organizations,[48] there is little to be gained by models in which profits, sales or other such tangibles provide a motivating force. As an alternative it was found necessary to employ a model in which utility itself was the maximand.[49] It was then possible to derive a set of testable hypotheses regarding the way certain variables could be expected to change in response to change in a parameter.

The following hypotheses were derived and tested: (1) the elasticity of mean stay and the elasticity of

cases treated with respect to per capita bed availability is greater than zero; and (2) the cases-treated elasticity is greater than the mean-stay elasticity. The statistical results confirmed these hypotheses in aggregate, although (not unexpectedly) hypothesis (1) was not born out for certain categorizations of the data.

CONCLUSIONS

A. SIMPLE REGRESSION MODEL

The explanation offered for the aggregative elasticities was based largely on the observation that the Alberta hospital system provided relatively more beds per capita than is the case either in Feldstein's British sample or in all other provinces in Canada.[50]

An integration of the excess capacity idea with the specified behavioral model led to the conjectured elaboration that observed utilization patterns may be largely the result of "administrators" tending to "pack" hospitals in areas where high per capita bed availability prevails.

Since probably the largest component of the "administrator" is medical practitioners, it also appears true that at least that portion of observed demand which fluctuates with bed availability is essentially generated by the medical practitioners. Evans has made a similar point:[51]

> "More realistically one could recognize that demand for hospital services is generated by medical practitioners who consult the relative costs and benefits of hospitalization to themselves and to their patients with weights that presumably vary from practitioner to practitioner."

B. MULTIPLE REGRESSION MODELS

It was possible to draw further general conclusions from several categorical breakdowns of the data. The rural-urban data categorization yielded tentative support (depending upon whether one accepts a 12 percent significance level) for the elaboration on the observed aggregative elasticities.

The results of the elasticity categorization by age group confirmed the basic hypotheses at this less aggregative level. The evidence also indicated that older people were the age group most affected by bed scarcity. In the case of the mean-stay elasticity, the 65 years and over group was associated with the highest elasticity. The responsiveness index for cases treated per capita indicated the 45 years and over group to be most elastic. This, of course, suggests that, where bed surpluses prevail, it has been found convenient to hospitalize older people more readily and retain them longer than is the case for other age groups.

Elasticities by diagnostic categories were also found to differ significantly from one another for both

mean-stay and cases-treated elasticities. The economist can draw few conclusions in this area due to relative ignorance of the nature and treatment of the various ailments.

POLICY IMPLICATIONS

It was suggested in Chapter II that the results of the study might have the potential to be used as monitoring information. Effective monitoring information would influence the behavior of decision-makers in such a way that private gains would have to be sacrificed for public gains. The private gains in this case would be those associated with physicians employing, at no charge, the services of complimentary factors of production (service provided by hospitals) for the treatment of cases of a marginally serious nature. Such cases, from a social point of view, would probably be better dealt with using facilities (doctor house calls, public health clinics, more treatment in doctors' offices, etc.) that the doctor himself must provide or that are supplied by the public for reasons of economy. In the former case, the burden is switched, to a greater extent, onto the doctors themselves, thus inducing a greater cost awareness. In the latter case (public health clinics), there is no private gain and presumably there are economies associated with intense usage of such a facility.

The prickly question here is whether monitoring information can be effective in inducing individuals to forego private gains. If this is not so, an alternative policy would be to reduce the supply of complimentary factors.[52] This would likely mean a rationalization of some acute hospitals in favor of fewer hospitals of near "optimal" size, spaced for a judicious protection of the public interest. In terms of the number of beds available there would be an absolute reduction (in Alberta) and a per capita reduction in certain areas. Clearly such a policy would put more demand pressure on the remaining hospital facilities and impose pressures on decision-makers to curtail the admission of cases of marginal need. If these hospitals are at present operating on the downward-sloping portion of their short-run average cost curves, an overall expenditure reduction could be achieved.

With regard to urban versus rural hospitals, there appear to be two alternatives if one wishes an equalization of bed availability:[53] an increase in urban bed capacity or a decrease in rural capacity. Assuming that the rural-urban drift will likely continue for some years and that urban hospitals may be the source of some bottlenecks, the over-capacitation of some rural hospitals threatens to get worse. It appears necessary to take the alternative of actually reducing (or phasing out) a portion

of the rural capacity. Contemporaneously it may be necessary to expand urban capacity for certain types of treatment. The results of this study do not permit consideration of this question.

One can surmise, from the elasticity categorization by age group, a need for a strengthened program which will provide the appropriate quantity of treatment facilities for older people. More auxiliary hospitals and nursing homes might go far to free scarce resources in acute hospitals.[54] If supplies of acute hospitals are cut back to levels where demand pressures are greater on those remaining, natural forces will push some patients into the available facilities more specially designed for their needs.

LIMITATIONS ON THE STUDY

SPECIFICATION

It is clear that the various models employed here have not been particularly successful in explaining the majority of the variation in mean stay and cases treated. The bane of good explanatory models, a low R^2, has been prevalent throughout much of the statistical section. In the traditional scheme of things this would probably be interpreted as a specification problem. However, there has been no pretension made that the dependent and independent variables in this study form a bivariate normal distribution. Consequently, to quote Fox:[55]

> "There are other cases in which the original values of X and Y, or transformed ones, are distributed in something other than normal fashion; in these cases, r may still be a rough estimation of the correlation in the universe, but we can no longer be sure that certain formulas appropriate to the normal distribution still apply ... In contrast, the interpretation of the regression coefficient ... is the same regardless of whether the X values are drawn at random or are subjected to purposeful selection."

While it is clear that, had one been interested in elaborate explanatory power for mean stay and cases treated, a much more comprehensive model would have been required; it remains true that the objectives of this study were not seriously affected.[56]

CONCLUSIONS AND IMPLICATIONS

It cannot be overstressed that the findings of this study apply to the system in the aggregate. To get at more specific areas, research is needed in a number of areas. First, there is a need for a less aggregative (micro) type of study of utilization patterns. This might permit steps to be taken toward a standardization of medical treatment procedures. Second, there is great need for research into comparative efficiency of hospitals in this system. This should be approached through the theory of production and cost. Estimation of long-run cost curves would provide insight to the question of "optimal" scale of operation. Short-run cost information would permit recommendations about the desired intensity of operation for a

hospital. Production theory and estimation could yield information on the problem of desirable factor mixes. Third and last, there appears to be a need for research into the desirable spatial orientation of hospitals in the system.

On completion of the above research a model can be assembled to answer the following questions: (1) What is the optimal size for a hospital? (2) What is the optimal intensity at which hospitals should be operated? (3) What are desirable factor mixes in hospitals? (4) Given the above information, what is a desirable spatial pattern in the hospital system? It is only when such questions can be answered that one can broach the question of an optimal supply program in the provision of hospital services.

It should be noted that a more elaborate micro-study awaits the ready accessibility of data with detailed breakdowns. For purposes of this study it would have been desirable to have had data breakdowns for individual hospitals of cases treated and mean stay by sex, age groups and diagnostic categories. Although such breakdowns are available there is great loss of real resources in recovering the information from government data tapes.

FOOTNOTES

1 "Expenditures - Personal Health Care in Canada" Research and Statistics, Dept. of National Health and Welfare, Ottawa, October 1970.

2 Canada, "Task Force Reports on the Cost of Health Services in Canada" (3 Volumes) Dept. of National Health and Welfare, November 1969.

3 "Expenditures on Personal Health Care in the Provinces of Canada: 1957-1970", Dept. of National Health and Welfare, November 1970.

4 M. S. Feldstein, Economic Analysis, p. 188.

5 H. Theil, Optimal Decision Rules for Government and Industry (Amsterdam, North-Holland Publishing Co., 1964) Chapter II.

6 Theil is concerned, in this case, with decision-making under certainty.

7 Unconstrained in the sense that the medical profession spares little to ensure their patients the best possible treatment.

8 The responsiveness indices to be used in this study will be elasticities with several valuable properties to recommend them:

(a) they are pure numbers and as such are free from unites of measure and scale considerations;

(b) elasticities are readily estimated in the form of slope coefficients when logarithmic transformations have been performed on the original data.

9 See T. C. Koopmans, Three Essays on the State of Economic Science (McGraw-Hill Book Co., 1957) Essay I.

10 See T. Negishi, "The Stability of a Competitive Economy: A Survey Article", Econometrica, 30, (1962), pp. 635-669.

11 See J. P. Newhouse, "Toward a Theory of Nonprofit Institutions: An Economic Model of a Hospital", American Economic Review, LX, No. 1 (March 1970).

12 Feldstein, Economic Analysis, p. 190.

13 Paul A. Samuelson, Foundations of Economic Analysis (Cambridge, Harvard University Press, 1963), pp.3-6.

14 The specification is credited to Feldstein, Economic Analysis, pp. 212-215.

15 That is $\frac{\partial^2 (\log U)}{\partial \log N \, \partial \log S} = \frac{\partial^2 (\log U)}{\partial \log N \, \partial \log Q} = \frac{\partial^2 (\log U)}{\partial \log S \, \partial \log Q} = 0$

16 See R. G. D. Allen, Mathematical Analysis For Economics (New York, St. Martin's Pres, 1967), pp. 301-302.

17 D is defined in terms of average cost per patient day.

18 This is borne out by the estimate of $\alpha = -0.192$ by Feldstein for the British case.

19 Equation (8) is not a simple transfer of (7). (8) is obtained by uniting (4), (5) and (6) in log form and maximizing log u subject to the log constraints.

20 Feldstein, Economic Analysis, pp. 213-215.

21 Samuelson, Foundations, pp. 23-24.

22 These assertions appear in Feldstein, Economic Analysis, pp. 216-217. It should be also be noted that although the hypothesis is couched in terms of increases in bed availability, the converse case of decreases in bed availability is also true.

23 This drift, if significant, would tend to create an upward bias in urban per capita bed supply.

24 See Footnote 5, Chapter I.

25 Analysis of covariance, in this study, permits one to test whether a single elasticity estimate should be made for a large set of observations or whether a data categorization is desirable so that a number of estimates can be obtained (one for each discernible partition of the data.)

26 The dummy variable approach to analysis of covariance is discussed by Damodar Gujarati in "Use of Dummy Variables in Testing for Equality between Sets of Coefficients in Two Linear Regressions: A Note," The American Statistician, February 1970.

27 Recall that observations are across hospitals so that i refers to hospital i.

28 This equation assumes that the coefficients $\hat{\alpha}_{s2}$ and $\hat{\eta}_{s2}$ are greater than zero for some given significance level.

29 It might be noted that the coefficient of determination in both equations is very low. Two factors may be cited to explain the casual acceptance of this fact:

(1) R^2 is often low in cross-section studies because of the differing random elements affecting the observations associated with the individual economic units.

(2) The range of variation in the observations is often limited.

30 Feldstein, Economic Analysis, p. 205.

31 Although the statistical results hold for the system there is no reason to expect that the results will conclusively hold for all components of the system.

32 Which, it is recalled, is a composite of doctors, nurses and the actual administrator.

33 This is not necessarily inconsistent with medical ethics since the patient is probably getting the best treatment at the physician's disposal.

34 R. G. Evans and H. D. Walker "Public Policy Problems in the Canadian Health Services Industry," Discussion Paper No. 39 of the Department of Economics, The University of British Columbia, Vancouver, B.C. p. 11.

35 See Chapter IV

36 This possibility is not at all remote as we note recent closures under similar circumstances in rural Saskatchewan.

37 This is reinforced by the fact of a lowly 65 percent utilization rate for the 100 hospitals in the sample.

38 Feldstein, Economic Analysis, pp. 205-206.

39 Beds used/1,000 population = Beds available/1,000 population x Utilization rate.

40 For notation see Chapter IV.

41 Op. cit., p. 205.

42 Chapter VII of Feldstein contains a number of tables where elasticities were categorized simultaneously by sex and disease category and by sex and age category. Such breakdowns were not possible for the present study due to an insufficient breakdown of the relevant data by the hospital data collectors.

43 It should be noted that this is an extrapolation from the system as a whole to various regions in the system. In effect, this comment may serve as a general rule of thumb but it is subject to severe

limitations when it is applied to inter-regional trends.

44 Tests indicate that none of the mean-stay elasticities are significantly less than zero at the 5 and 10 percent level. This implies that while the disaggregate results do not clearly support our aggregate hypothesis in every case (the hypothesis referred to is that the mean-stay elasticity is greater than zero), one at least has the satisfaction of knowing that there has not been a reversal of the direction of change.

45 Feldstein, Economic Analaysis, p. 220, notes that the seriousness of these diseases is indicated by the fact that one-fifth of cancer patients and one-third of those suffering from arteriosclerotic and degenerative heart disease die in hospital.

46 Op. cit., p. 221.

47 Evans and Walker, "Public Policy Problems."

48 For a contribution toward the theory of non-profit institutions see J. P. Newhouse, "Toward a Theory of Non-profit Institutions: An Economic Model of a Hospital," The American Economic Review, Volume LX, No. 1, March 1970.

49 The whole area of utility and utility functions has created extended controversy over the quantification problem. This is an area where an inter-disciplinary approach should be taken in order to utilize the skills of sociologists, pyschologists, etc.

50 Evans and Walker, "Public Policy Issues," p. 8, provide outside support for the excess capacity idea by suggesting it's prevalence in much of Canada:

"In the hospital industry...Canada has too many acute care hospital beds and other treatment facilities, a problem reflected in vacant beds, unnecessary admissions, and overly prolonged stays."

51 Robert Evans, "Behavioral" Cost Functions for Hospitals, Discussion Paper No. 39, Department of Economics, University of British Columbia, p. 3.

52 Actually, even effective use of monitoring information should ultimately have this effect since facilities would then be even more underutilized and some rationalization of facilities would be called for.

53 This assumes that an equalization of opportunity (in terms of per capita bed availability) among different groups in the province is desirable.

54 It should be noted that Alberta, particularly since 1968, has taken concrete steps in this direction.

55 Mordecai Ezekiel and Karl A. Fox, Methods of Correlation and Regression Analysis, (New York, John Wiley and Sons) 1965, p. 130.

56 For a discussion of issues related to regression and correlation see, T. W. Wonnacott and R. J. Wonnacott, Introductory Statistics (Toronto, John Wiley and Sons), 1969, Chapter 14.

BIBLIOGRAPHY

ARTICLES AND PERIODICALS

Arrow, Kenneth J.
"Uncertainty and the Economics of Medical Care", The American Economic Review, Vo. LIII, No. 5 (December 1963).

Gujarait, Damodar
"Use of Dummy Variables in Testing For Equality Between Sets of Coefficients in Two Linear Regressions: A Note," The American Statistician (February 1970).

Jeffers, J. R., Bognanno, M.F. and Bartlett, J.C.
"On the Demand vs. Need for Medical Services and the Concept of Shortage", American Journal of Public Health (September 1970).

Negishi, Takashi
"The Stability of A Competitive Economy: A Survey Article", Econometrica, No. 30 (1962).

Newhouse, J. P.
"Toward A Theory of Non-profit Institutions: An Economic Model of a Hospital", The American Economic Review, Vol.LX, No. 1 (March 1970).

BOOKS

Allen, R. G. D.
Mathematical Analysis for Economists (New York, St. Martin's Press, 1967).

Chiang, Alpha C.
Fundamental Methods of Mathematical Economics, (Toronto, McGraw-Hill, 1967).

Exekiel, M. and Fox, Karl A.
Methods of Correlation and Regression Analysis, (New York, John Wiley and Sons, 1965).

Feldstein, Martin S.
Economic Analysis for Health Service Efficiency, (Chicago, Markham Publishing Co., 1968).

Koopmans, T. C.
Three Essays on the State of Economic Science (Toronto, McGraw-Hill, 1957).

Theil, H.
Optimal Decision Rules for Government and Industry (Amsterdam, North-Holland Publishing Co., 1964).

Samuelson, Paul A.
Foundations of Economic Analysis (Cambridge, Harvard University Press, 1947).

Wonnacott, Ronald J. and Wonnacott, Thomas H.
Introductory Statistics (Toronto, John Wiley and Sons, 1969).

PUBLIC DOCUMENTS

Alberta, Annual Report of the Alberta Hospitalization Benefits Plan, Department of Health of the Province of Alberta, 1968.

Canada, Hospital Indicators, Quarterly, Dominion Bureau of Statistics, Catalogue No. 83-001, 1st issue, 1969.

Canada, The Public Finance Aspects of Health Services in Canada, Royal Commission on Health Services (Ottawa, Queen's Printer, 1963).

Canada, Task Force Reports on the Cost of Health Services in Canada (3 volumes) (Ottawa, Queen's Printer for the Department of Health and Welfare, November 1969).

UNPUBLISHED

Evans, Robert
"Behavioral" Cost Functions for Hospitals, Discussion Paper No. 38, Department of Economics, University of British Columbia.

Evans, Robert and Walker, Hugh D.
"Public Policy Problems in the Canadian Health Services Industry", Discussion Paper No. 39, Department of Economics, University of British Columbia.

[illegible], T. C.
Hypotheses of the Study of [illegible] Science (Toronto, McGraw-Hill, 1957).

[illegible], H.
[illegible] for [illegible] and [illegible] [illegible], [illegible], 1964).

Samuelson, Paul A.
Foundations of Economic Analysis (Cambridge, Harvard University Press, 1947).

[illegible], [illegible] Introduction [illegible] (Toronto, John Wiley and Sons, 1962).

GOVERNMENT DOCUMENTS

Alberta, Annual Report of the Alberta Hospitalization [illegible], Department of [illegible] of the Province of Alberta, 1962.

Canada, Hospital Indicators Quarterly, Dominion Bureau of Statistics, Catalogue No. 83-001, (Ottawa, 1963).

Canada, The Royal Commission Report on Health Services in Canada, [illegible] Services (Ottawa, Queen's Printer, 1962)

Canada, Task Force Reports on the Cost of Health Services in Canada [illegible] (Ottawa, Queen's Printer for the Department of National Health and Welfare, November 1969).

UNPUBLISHED

Evans, Robert
"Behavioral" Cost Functions for Hospitals, Discussion Paper No. [illegible], Department of Economics, University of British Columbia.

Evans, Robert and Walker, Hugh D.
"Public Policy Problems in the Canadian Hospital [illegible]", Discussion Paper No. [illegible], Department of Economics, University of British Columbia, [illegible].